RISK IN THE ACQUISITION PROCESS

A Better Concept

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Acquisition management is risk management. It consists of identifying risks associated with cost, schedule and performance, and then managing those risks to minimize overall program risk. In their guidebook, *Risk Management Concepts and Guidance*, the Defense Systems Management College (DSMC) develops a framework for risk management for acquisition. This excellent model defines risk as "the probability of an undesirable event occurring and the significance of the consequence of the occurrence." In practical application, this means the acquisition manager must use a certain amount of subjective judgment to assign probabilities and consequences. Additionally, he or she must use judgment to determine the risk resulting from the relationship between those probabilities and consequences. Several models exist to help with the latter, but they are not consistent and tend to be somewhat imprecise.

In this article, I examine the relationship between probabilities and consequences and propose a more precise model that will reduce the reliance on subjective managerial judgment when assessing risk.

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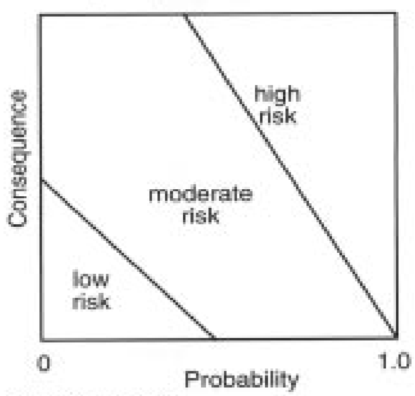
Figure 1. Flying Safety Concept of Risk



Source: AFFTCR 127-3

Background

In my experience as an Air Force flyer, I became familiar with the flying safety community's concept of risk as shown in Figure 1. This concept shows that an event with a low probability of occurrence and a low consequence if it does occur would present a low risk. On the other hand, an event with a high probability of occurrence and a catastrophic consequence would present a high risk. The area in between represents a transition from low to high risk, and we label it moderate risk.

The DSMC presents two slightly different concepts of risk, as shown in Figures 2 and 3. Note in these concepts the axes are the reverse of the flying safety concept.

All the concepts agree that a risk-rating system should be kept simple with low, moderate and high designations. They also agree that the lower left quadrant generally represents low risk and the upper right quadrant generally represents high risk. They differ in how the other two quadrants are interpreted:

— High probability, low consequence. In Figure 2, the first DSMC concept, the upper left quadrant represents low risk. In Figure 3, the second concept, the upper left quadrant generally represents moderate risk. This corresponds to the lower right quadrant of the flying safety concept in Figure 1, which also generally represents moderate risk.

Figure 2. DSMC Concept of Risk

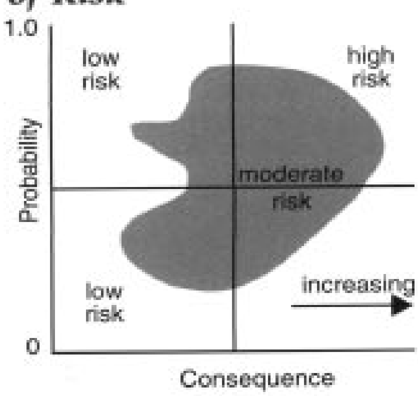
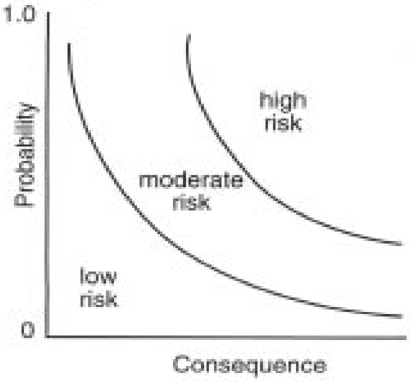


Figure 3. DSMC Risk Rating



— Low probability, high consequence. Interestingly, DSMC illustrates this quadrant with an example based on flying safety: flying in a commercial airliner is low risk because, although the consequences of a crash are severe, the probability is low. However, in Figure 1, the flying safety concept would classify this condition as moderate risk. The second DSMC concept, Figure 3, represents this quadrant as generally representing moderate risk, but it also reflects the low risk nature of this example. The first DSMC concept, Figure 2, represents this quadrant as "increasing risk" and describes it as "more subject to individual interpretation and requires strict program guidelines for rating the risk."

The DSMC hones the concept of risk by differentiating it from uncertainty. Risk stems from an event associated with a known probability distribution. Uncertainty stems from an event associated with an unknown probability distribution. In actual practice, especially in the acquisition world, probability distributions are never very well known. Normally, we apply judgement to make various assumptions to achieve acceptable approximations. Finally, in their discussion of rating schemes and definitions, DSMC concludes, "The definition issue becomes one of identifying impacts and deciding on a scale(s) and then shaping the boundaries between the three regimes." They recognize that judgment is required for each of these endeavors. I propose that shaping the boundaries can be more objective and less reliant on judgment.

Shaping the Boundaries

The foregoing discussion showed an obvious lack of agreement on the shape of the boundaries between risk levels. In this section, I offer some assertions to add more precision to the shape of the boundary curves.

• Assertion 1. Probability is the independent variable and should be on the x axis. Although the axis selection is somewhat arbitrary and the same results will be achieved either way, it is important to establish a convention so everyone has the same point of reference. I contend that an event must occur before a consequence results. In other words, the consequence is dependent on the event occurring which is represented by probability. Figure 1 reflects this assertion.

• Assertion 2. Probability is bounded at both ends, consequence is only bounded at the lower end. By definition, probability can only assume values between 0 and 1 inclusively. Some events can have a 0 consequence, but other events can have unmeasurably high consequences. Furthermore, consequences cannot be negative. From the DSMC definition of risk, we are dealing only with undesirable events. A negative consequence would, therefore, represent a desirable event and is incompatible with the concept of risk. In fact, the favorable results of a particular event become the subject of another decision after the risk is determined — the acquisition manager must weigh the risks of a particular action against the benefits.

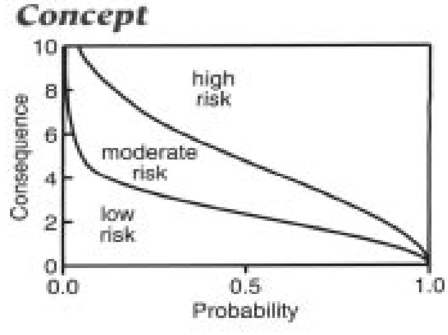
• Assertion 3. As probability approaches 1.0, risk becomes undefined. Whether the consequences are grave or negligible, the event is imminent. The problem becomes one of damage control, not risk management. None of the risk concepts presented earlier reflect this assertion adequately.

• Assertion 4. At probability 0, risk is in the low regime. Whether the consequences are grave or negligible, the event is not possible. No risk is associated with a nonevent. Figures 2 and 3 reflect this assertion.

• Assertion 5. The nature of the risk is different on each side of the point where probability is 0.5. This assertion reflects an intuitive sense about risk. You tend to manage things differently if the odds are against rather than if the odds are with you. Figure 2 reflects this assertion by separating quadrants at the point where $x = .5$.

What sort of graphical concept reflects all of these assertions? I offer the concept shown in Figure 4. Assertion 1 obviously is incorporated. Assertion 2 is satisfied by the asymptotic nature of the curves as x approaches 0. A finite difference exists between risk levels at any conceivable consequence level. Assertion 3 is satisfied by the curves converging at the point where probability is 1. At that point, risk is neither low, moderate nor high; it is undefined. The curves converge rather steeply to that point to reflect the fact that, even though imminent, an event with very little consequence is certainly not a high risk and hardly a moderate risk. Assertion 4 is satisfied by the asymptotic nature of the

Figure 4. A Better Risk Concept



curves as they approach $x = 0$. A highly unlikely event is low risk even if the consequences are catastrophic. Recall the example of flying on a commercial airliner. Assertion 5 is satisfied by the inflection point at $x = .5$. When $x < .5$ the slopes of the curves are increasing, similar to the curves in Figure 3. When $x > .5$, however, the slopes are decreasing. Although the change is very gradual, the nature of risk is different on either side of the break-even odds.

If you are familiar with statistics, you may recognize these curves as Gaussian, or bell-shaped, curves that have been rotated sideways. The Gaussian function occurs throughout nature from nuclear physics to biology to cosmology. I cannot rigorously prove that it also applies to boundaries between risk levels, but it is certainly intuitively appealing to use it. The appendix contains more detail on the actual mathematical expressions. Selecting coefficients to vertically position the curves belongs in the same decision arena as determining the scale for the y axis and no doubt requires judgment. For this presentation, I selected coefficient values so the tangents to the points where $x = .5$ have slopes of -3.33/1 and -6.67/1 for the lower and upper curves, respectively. Other than making this decision about scale, no other judgment is required to determine the actual shape of the risk boundary curves.

Conclusion

The concept of risk is fundamental to the acquisition system. A concrete risk concept would minimize error propagation throughout the entire risk management process. Unfortunately, the process of assessing risk is nonrigorous, subjective and relies heavily on judgment. The concept I presented in this article adds some measure of objectivity to the risk assessment process by defining the shape of the curves separating the risk regimes. The risk assessment process is still very imprecise and a great deal of judgment is required to assign probability and consequence values to a range of possible events. With this concept of risk, however, less judgment is required when examining the combination of the two.

References

Risk Management Concepts and Guidance. Defense Systems Management College. Washington: U.S. Government Printing Office, 1990.

"Safety Planning for AFFTC Projects." AFFTCR 127-3. Edwards AFB, Ca, 11 January 1990.

THE GAUSSIAN FUNCTION

The familiar bell-shaped curve is expressed by the Gaussian function:

$$Y = ae^{-bX^2}$$

To represent the curves shown in Figure 4, we need to rotate the curves 90 degrees clockwise. To do so, we make the following substitutions:

$$X = y \qquad Y = -x$$

So, the equation becomes:

$$-x = ae^{-by^2}$$

algebraically rearranging produces:

$$y = \sqrt{-\tfrac{1}{b}\ln(-\tfrac{1}{a}x)}$$

The constant, $-\frac{1}{a}$, determines the x-intercept of the curve. To comply with assertions 2 and 3, we want the curves to intercept the x axis at $x = 1$. Furthermore, the argument of the natural log must be greater than 0. Therefore, we choose $a = -1$. Let us also define another constant:

$$k = \sqrt{\tfrac{1}{b}}$$

This constant determines the slope of the curve at any given value of x which also determines the vertical spread of the curve.

So, the final expression for our curves is:

$$Y = k\sqrt{-\ln x}$$

As mentioned in this article, we also are interested in the slopes of the curves, specifically at $x = .5$. We know that the slope, m, is equal to the first derivative of the equation for y:

$$m = dy/dx$$

$$= 1/2\ k\ (-\ln x)^{-1/2}(-1/x)$$

Setting $x = .5$ and solving for k in terms of m, we arrive at:

$$k = -.833\ m$$

In this model, I arbitrarily selected slopes for the upper and lower curves to be -6.67 and -3.33, respectively. This results in values for k being 5.55 and 2.77, respectively.